VERDE-GALLUP POOL, SAN JUAN COUNTY, NEW MEXICO

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INTRODUCTION

Although it was the first of three major oil areas discovered in late 1955 and early 1956 in the Four Corners region, the Verde-Gallup pool has received little of the recognition afforded its more prolific sisters, Bisti and Aneth. However, in terms of long range geological and economical significance, it may well outrival its illustrious companions. From a geological standpoint the challenge offered is definitely more complicated.

The Verde-Gallup pool, as the field was designated by the New Mexico Oil Conservation Commission on January 30, 1957, lies approximately 14 miles northwest of Farmington, New Mexico. Most of the area is readily accessible by road, however, the field for the most part lies on and around steeply dipping outcrops of the Mesaverde formation, and the terrain is moderately to extremely rugged.

HISTORY

The discovery well of the Verde-Gallup pool was the C. M. Carroll No. 1 Ute drilled on a farmout from El Paso Natural Gas Company in the SE¼ of Sec. 14, T31N, R15W, San Juan County, New Mexico. On September 20, 1955, this well was completed naturally on pump for 180 BOPD of 42° gravity oil at depth of 2400 feet. The majority of acreage in the vicinity of the well was put up for leasing on two sealed-bid sales held the following December and April by the Ute Mountain Indian tribe. Top bid on these sales was $267.12 per acre paid for a 1,280-acre tract by Tennessee Gas Transmission Company.

Other acreage holders in the area include Atlantic Refining Company, Aztec Oil & Gas Company, C. M. Carroll, El Paso Natural Gas Products Company, Gulf Oil Corporation, Pan American Oil Corporation, Pubco Petroleum Corporation, Southern Union Gas Company and Standard Oil Company of Texas. During the initial stages of development, drilling was desultory, no doubt influenced by two facts: (1) the discovery well was a geological enigma, and (2) the contemporaneous discoveries at Bisti and Aneth diverted attention and offered the geologist an opportunity to ignore the puzzle in favor of problems lending themselves more readily to interpretation and evaluation. However, after the sporadic start, the subsequent development has been a steady rate, and up to August 1, 1957, fifty wells had been completed, twelve were drilling and seven locations had been made. Of the completed wells forty-nine produce on pump and only one has been abandoned. All but four have been stimulated by fracturing treatments. The majority of drilling has been on an eighty-acre spacing pattern although no governmental regulations have yet been instituted. The above data does not include the widely heralded Horseshoe Canyon area of Gallup production lying to the southwest of the Verde field. This area is considered to result from different stratigraphic and structural relationships and will be treated only briefly elsewhere in this discussion.

STRATIGRAPHY

The section drilled in the Verde-Gallup field is entirely of Upper Cretaceous age. Wells are spudded in either the Lewis shale or one of the two upper members of the Mesaverde formation, the Cliff House sandstone and the Menefee formation. Beneath the sands, shales and coals of the Menefee is the massive Point Lookout sandstone member of the Mesaverde.

The Point Lookout grades transitionally into the underlying marine shales of the Mancos formation. The upper Mancos is approximately 1200 feet in thickness and overlies the Gallup sandstone member of the Mesaverde formation. The lower portion of the Gallup interval is the productive horizon at Verde and is described as a series of interbedded gray, medium- to fine-grained, calcareous and shaly sandstones and dark gray, calcareous shales. The Gallup sand in the field area represents the final regressive phase of a northeastward retreating sea and, due to its dominantly marine characteristics, might more logically be referred to as the Niobrara member of the Mancos shale. This is particularly true in the more northern portion of the field, where the Gallup may be recognized only by characteristically high resistivity deflections of the electrical log. Southwestward toward the source area the sand content in the producing interval increases, as would normally be expected (Fig. 3). The base of the Gallup is marked by the calcareous siltstones of the Sanastee member of the Mancos shale which is also more readily defined by electrical log characteristics than by sample examination. It should be noted that in the Horseshoe Canyon area (Fig. 1, Composite Log) a well-developed sand immediately overlies the Sanastee and in some instances apparently replaces the uppermost Sanastee stringers. This sand is the primary producing horizon at Horseshoe Canyon and occupies a stratigraphic position analogous to the subsurface "Tocito" of the Lowry field (Bozanic, 1955, p. 95). This sand is a lenticular sand clean-up paralleling the ancient strandline and is apparently of a relatively localized nature. It has not been found developed in the Verde field proper,

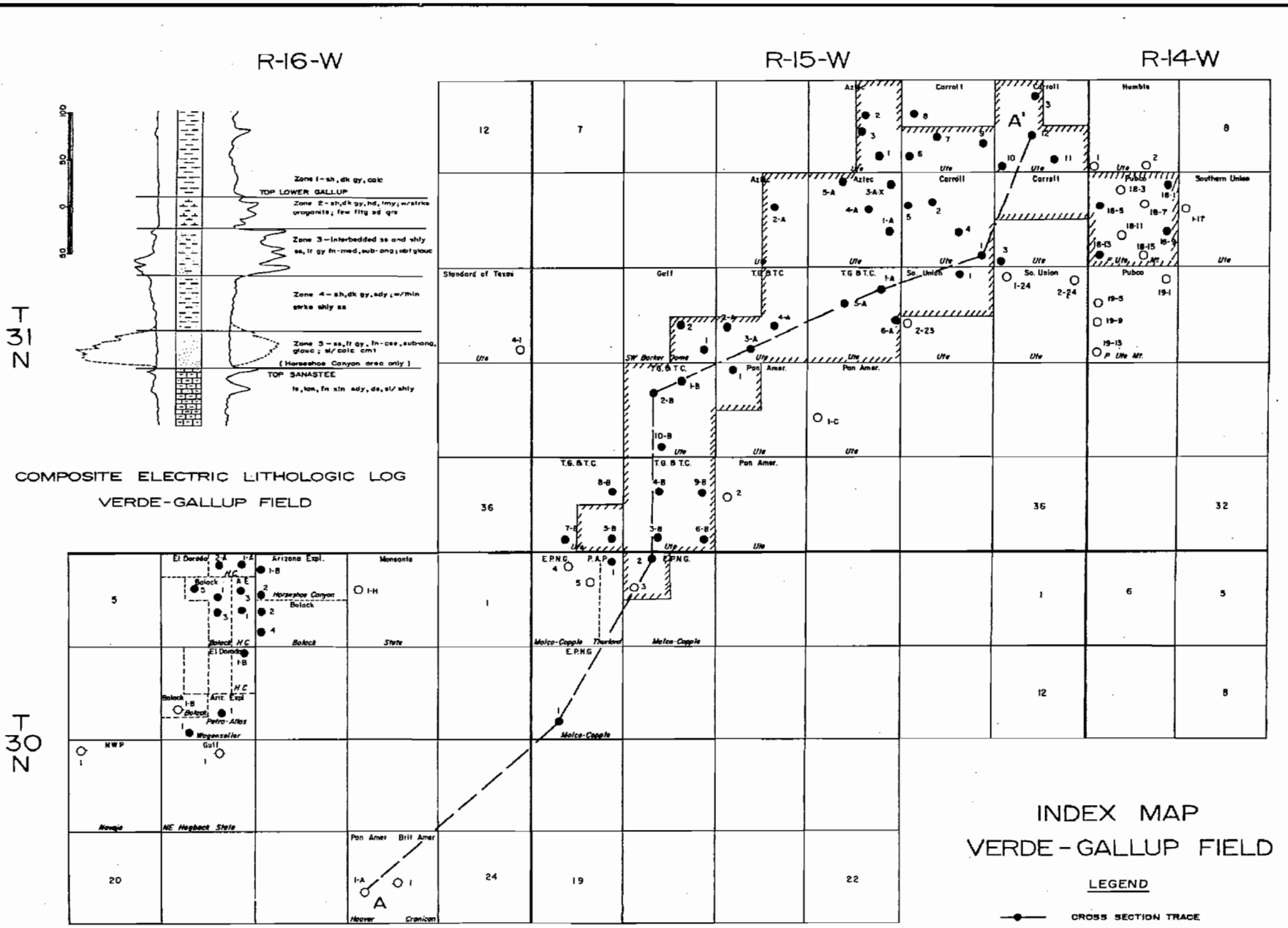

R-16-W
R-15-W
R-14-W
T 31 N
T 30 N
100
50
0
50
Zone 1 – sh, dk gy, calc
TOP LOWER GALLUP
Zone 2 – sh, dk gy, hd, fmy; w/ stria organite; few fltg sd qrs
Zone 3 – interbedded ss and shly ss, lt gy fn-med, sub-ang; abt glauc
Zone 4 – sh, dk gy, sdy; w/ thin strks shly ss
Zone 5 – ss, lt gy, fn-cse, sub-ang, glauc; w/ calc cmt
(Horseshoe Canyon area only)
TOP SANASTEE
ls, tan, fn xln sdy, ds, sl/ shly
COMPOSITE ELECTRIC LITHOLOGIC LOG
VERDE-GALLUP FIELD
A
A'
Aztec
Carroll
Humble
Southern Union
Standard of Texas
Gulf
T.G.B.T.C.
So. Union
Pubco
Pan Amer.
Ute
SW Barker Dome
El Dorado
Arizona Expl.
Monsanto
Horseshoe Canyon
Bolack
State
E.P.N.G.
P.A.P.
Malco-Capple
Thurland
Petro-Atlas
Wagenseller
NWP
Navajo
NE Hogback State
Pan Amer
Brit Amer
Hoover
Cranicon
INDEX MAP
VERDE - GALLUP FIELD
LEGEND
CROSS SECTION TRACE
VERDE-GALLUP POOL OUTLINE 8-1-67

FIGURE 1

although few wells have penetrated deeply enough to determine the presence or absence of this horizon.

STRUCTURE

Of primary importance to the accumulation of oil at Verde-Gallup is the unique structural position of the field. The pool lies along and northwest of the Hogback monocline, a prominent structural feature which is expressed at the surface by steeply dipping outcrops of the Mesaverde formation. The gently eastward dipping Upper Cretaceous beds of the San Juan Basin are abruptly flexed along this monocline and it is noteworthy that the production to date is limited almost entirely to the upper anticlinal bend of the monocline (Fig. 2. Surface dips range from 7° to 45°; however, the maximum dip on the top of the Lower Gallup is approximately 15°.

THEORY OF ACCUMULATION

All evidence points towards the fact that the Verde-Gallup pool is producing from a fractured reservoir.

From cores and electrical logs of the initial wells in this field it was apparent that the sandstones present in the Lower Gallup section did not have the reservoir characteristics necessary to support the amount of oil the wells were producing. Core analyses indicate these sands, where developed, have satisfactory oil and water saturations, but the porosities and permeabilities are much too low (average 7.5% and 0.18 millidarcies) to establish adequate reservoir beds. Drilling difficulties such as extremely bad lost circulation zones, bit locking and jumping, and very poor core recoveries lent support to the possibilities of subsurface fracturing. An abundance of calcite, a fissure filler, was noted in ditch samples.

In one case the loss of circulation in a drilling well was noted to have a marked effect on the productive capacity of an adjacent well. Oil entry into the hole during completion of early wells appeared to have little regard for lithologic boundaries. Selective perforation and sand-oil fracturing of the Lower Gallup interval yielded the information that each of the five lithologic zones shown on the composite log (Fig. 1) has produced oil individually in at least one instance in the field area. More recently bottom hole interference tests conducted by one operator have indicated some communication between wells, although the tests were not considered to have been conclusive. (Clovis Rodelander, oral communication). The best evidence yet obtained has been the visual evidence of vertically fractured cores of shale and siltstones with live oil along the fracture planes.

The fractured nature of the reservoir establishes the field as primarily a strucutral trap directly related to the monocline along which it lies. The formation of this monocline during early Tertiary time created stresses which were relieved by fracturing rather than flexing in the relatively brittle and shallow Gallup sandstones, siltstones and silty shales. The adjacent fossiliferous marine shales of the Mancos formation are considered to provide the source of the petroleum occuring in the Lower Gallup section. Maximum fissuring apparently occurs along a line paralleling the strike of the anticlinal bend of the monocline and to a lesser extent along its steeply dipping limb. This orientation of the fracture system parallel or possibly slightly oblique to the trend of the monocline would seem to indicate that the formation of the Hogback monocline in the field as primarily a structural trap directly related to compressional rather than to tensional forces.

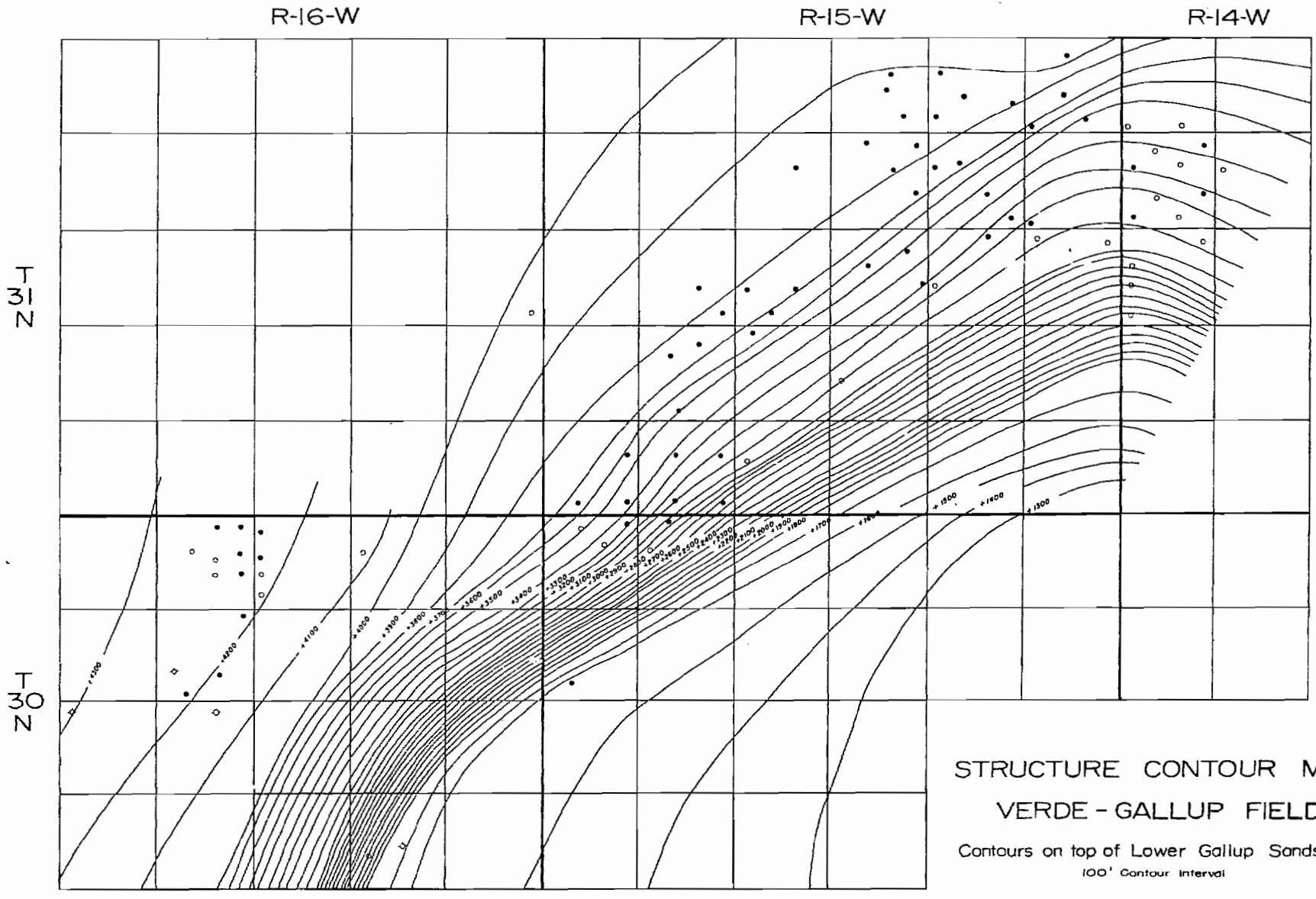
Kelley has favored the compressional theory of formation in his discussion of the regional tectonics of the area (Kelley, 1955, p. 67-69), believing the monocline to result from crowding action of the uplifts ringing the north and west sides of the San Juan Basin rather than the tensional action of basin subsidence.

Some limited stratigraphic control of the field may be introduced by virtue of the regressive Lower Gallup interval exhibiting a general increase of sand content towards the southwest or source direction. This transitional change in the lithologic characteristics of the productive zones may affect their reaction to fracturing stresses and thus limit production in a southwestward direction. Present information, however, neither substantiates nor disproves this possibility.

Geologically the Verde-Gallup pool has two very old and venerable counterparts in the Florence-Canon City and Rangely fields in Colorado. Both of these fields have produced substantial amounts of oil from fractures in the Mancos shale. Production figures show Rangely to have produced a total of 4,778,005 barrels from 1902 through 1953, and Florence-Canon City to have produced 14,122,042 barrels from 1887 to 1953. (Oil and Gas Fields of Colorado, a Symposium, Rocky Mountain Association of Geologists, 1954, p. 137 and 255). At Rangely the fractures occur along the steep flank of an asymmetrival anticline; however, at Florence-Canon City the similarity to Verde is even more marked, as the field is productive from fractures occurring adjacent to a steep monocline. In his discussion of the oil accumulation in the Florence field, DeFord has theorized that the deforming forces which created the monocline also created "stored up" stresses within the shale section. As the shale was bounded on top and bottom by more competent sandstone, these stresses went unrelieved until erosion of the upper sand occurred in relatively recent time. The removal of this restraining sandstone allowed fissures to open, and the disseminated oil indigenous to the shale accumulated in these openings (DeFord, 1928, p. 86-87). Although this hypothesis is not considered to be completely applicable to Verde-Gallup, the parallelism of the two occurrences is noteworthy.

COMPLETION METHODS

Completion methods employed in the Verde field have been varied. Rotary rigs have been used to drill holes to



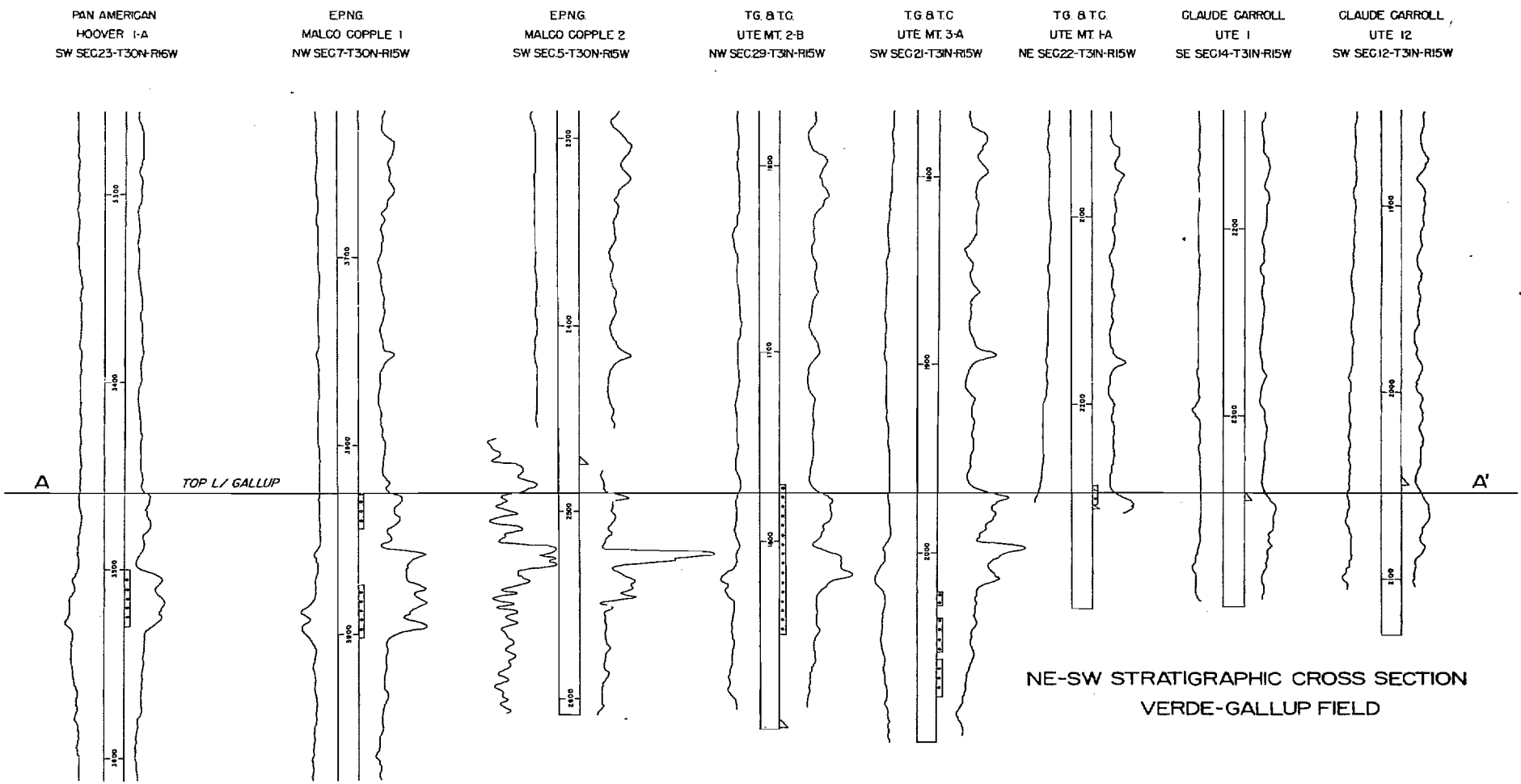
STRUCTURE CONTOUR MAP

VERDE - GALLUP FIELD

Contours on top of Lower Gallup Sandstone

100' Contour Interval

FIGURE 2



NE-SW STRATIGRAPHIC CROSS SECTION
VERDE-GALLUP FIELD

FIGURE 3

total depth with the casing either being run to total depth and perforated or "swung" off of the top of the pay zone for an open hole completion. In some instances a rotary has been used to drill to the top of the Lower Gallup where pipe is set and a cable tool rig employed to drill the pay zone. The most commonly accepted completion method has been to rotary drill to a point just off the top of the Lower Gallup, run casing and core or drill in the pay section, with the rotary rig employing crude oil as a circulating medium. The open hole has then been sand-oil fractured with treatments averaging 45,000 gallons of oil with 60,000 pounds of sand. In some cases a slotted liner is run to protect the pay section from sloughing.

PRODUCTION DATA

The Verde-Gallup pool has produced a total of 334,633 barrels of 38° to 42° gravity oil through July of 1957.

There has been no apparent decline in productive capacity of the wells in the pool; however, the output has been restricted since May, 1955 due to lack of market outlets. The present field allowable is 12 BOPD per well. Regarding productive capacity, it is interesting to note that in the discovery well, Carroll's No. 1 Ute, the daily capacity increased appreciably during the first eight months in which production was unrestrained. The well was potentialed for 180 BOPD and had subsequently advanced to 210 BOPD just prior to curtailment of oil purchases.

Gas-oil ratios in the pool have ranged from 40 to 1583 cubic feet per barrel with an average of approximately 325 cubic feet per barrel. Bottom hole pressures at a datum of +3400 feet range from 130 lbs. to 462 lbs., with an average of around 410 lbs. There has been no noticeable decline in bottom hole pressures in the field, although some tests have indicated erratic changes in pressure in individual wells, which may be attributed to oil migration in the fracture reservoir. Tests run by two operators in the area have indicated that the bubble point pressures will range between 250 and 300 lbs., which indicates the reservoir to be undersaturated. The field drive is dissolved gas with a possible gravity assist. To date no formational water has been reported in the pay section of the field area.

SUMMARY AND CONCLUSIONS

The Verde-Gallup pool is producing oil from fractures within the final regressive phase of the Lower Gallup sandstone and shale interval. The fracture system is intimately related to the structural Hogback monocline, and results from the response of incompetent beds to the relatively abrupt compressional flexing which occurred along this monocline through early Tertiary time. Production to date has been limited primarily to the anticlinal bend of the monocline. The regressive nature of the productive zones may exert some stratigraphic influence on the field. The limits of the field are presently undefined.

Production data are too inconclusive to indicate the capacity and longevity of the field, however, the field as a whole compares favorably to the very old and prolific Florence-Canon City field of southeastern Colorado.

ACKNOWLEDGEMENTS

The writer wishes to express thanks to El Paso Natural Gas Products Company for permission to publish this report compiled from data made available from their files. Thanks are also due to Del Talley of EPNG's drafting department and M. L. Matheny of the geological department for work on the included illustrations, and to M. L. Matheny for comments and criticism of the report.

REFERENCES CITED

Bozanic, Dan (1954), "A Brief Discussion on the Subsurface Cretaceous Rocks of the San Juan Basin," Four Corners Field Conference, Four Corners Geological Society, p. 95.

Brunton, A. F. (1954), "Florence-Canon City Field," Rocky Mountain Association of Geologists Symposium on Oil and Gas Fields of Colorado, p. 137.

DeFord, R. K. (1928), "Surface Structure, Florence Oil Field, Fremont County, Colorado," American Association of Petroleum Geologists Symposium on Structure of Typical American Oil Fields, Vol. II, p. 86 and 87.

Kelley, V. C. (1955), "Regional Tectonics of the Colorado Plateau and Relationship to the Origin and Distribution of Uranium," University of New Mexico Publications in Geology, No. 5, p. 67-69.

Rodelander, Clovis, Oral Communication.

Smith, W. R. (1954), "Rangely Field," Rocky Mountain Association of Geologists Symposium on Oil and Gas Fields of Colorado, p. 255.